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Heat exchanger, in particular for motor vehicles

The invention relates to a heat exchanger, in particular for motor vehicles, for a first and a second flow medium, in particular as described in the preamble of patent claim 1.

To increase their power, internal combustion engines for motor vehicles are supercharged, the charge air, after it has been compressed in the charger, being cooled by a charge-air cooler in order to increase the delivery. The trend in modern internal combustion engines is toward higher powers and therefore also toward higher charge pressures, which is made possible in particular by improved chargers, for example what are known as VTG (variable turbine geometry) chargers. In some cases, two-stage supercharging is also carried out, in which case intercooling of the charge air is provided for between the two stages. Accordingly, charge-air systems of this type require a charge-air intercooler. The boosted supercharging results in higher charge-air temperatures, which can no longer be dealt with using conventional charge-air coolers. Known charge-air coolers in some cases have plastic collection headers, but these can only be used up to temperatures of approx. 200 degrees Celsius. Above this temperature threshold up to approximately 260 to 270 degrees Celsius, aluminum collection headers, which are more thermally stable, are used for charge-air coolers. If it is desired to continue to use these conventional charge-air coolers, i.e. at higher charge pressures and charge-air temperatures, it is necessary to include a primary cooler, i.e. the charge air is cooled in two stages, specifically to preferably below approximately 260 degrees, by the primary cooler. The latter therefore has to be particularly thermally stable.

The charge air in the charge-air cooler of motor vehicles is generally cooled by ambient air, in which case the charge-air cooler is arranged in the front engine compartment of the motor vehicle in the region of a coolant/air radiator. In some cases, however, liquid-cooled charge-air coolers are also used, in which the coolant from the engine cooling circuit cools the charge air. One drawback of known charge-air coolers (cf. DE-A 199 53 787 and DE-A 199 53 785) is the diversion of the charge air into the air headers, which leads to a pressure loss. Other designs, for example plate or stacked plate heat exchangers as described in DE-A 195 11 991, have an increased pressure loss on account of the double diversion of the charge air through 90 degrees.

Designs in which the pressure loss on the primary side has been reduced by avoiding diversions are known from the field of exhaust-gas heat exchangers, for example from DE-A 199 07 163 in the name of the Applicant or WO 00/26514. These heat exchangers each have tube bundles, tube plates, housings and exhaust-gas connection pieces, which are welded or soldered to one another. This involves a large number of parts and a large number of manufacturing steps, i.e. entails increased production costs.

It is an object of the present invention to provide a heat exchanger of the type described in the introduction which is thermally stable up to approximately 300 degrees Celsius and possibly even above and has a preferably relatively low pressure drop on the gas side, and which can also preferably be produced at low cost.

This object is achieved by the features of patent claim 1. According to the invention, it is provided that the tube bundle and one of the two tube plates are formed integrally and can be produced by the impact extrusion process which is known per se. Impact extrusion is a known technology related to other forms of extrusion, in which a billet is forced through a shaping tool (die) (cf. Dubbel, Taschenbuch für den Maschinenbau [Mechanical Engineering Handbook], 20th edition, p. 30). The material used is preferably an aluminum extrusion alloy which is especially suitable for impact extrusion. The product produced by impact extrusion in this way is a finished tube plate which is seamlessly and integrally adjoined by all the tubes of the tube bundle. This has the advantage that firstly there is no need for separate production of the tube plate and the tubes and secondly the complex joining of tubes and tube plates, for example by welding or soldering, is eliminated. This considerably reduces production costs. The remaining parts, such as the second tube plate, the housing and the connection pieces, consist of aluminum materials and are joined to the impact-extruded part in a conventional way, for example by soldering or welding. A further advantage is that it is possible to produce any desired tube cross section, whether round or polygonal, by impact extrusion. A further advantage is that the tubes of the tube bundle can be produced in any desired length and wall thickness. The thermal stability is also achieved by a low-stress geometry of the all-aluminum heat exchanger according to the invention.

According to an advantageous configuration of the invention, the housing can also be produced by impact extrusion, i.e. in a single operation with the tube plate and the tube bundle. This has the advantage of further simplifying production and reducing the costs

of the heat exchanger according to the invention. To complete the heat exchanger, it is merely necessary for the second tube plate and the connection pieces to be joined to the impact-extruded part.

According to an advantageous configuration of the invention, the transition region between the tubes and the tube plates is configured to be round, i.e. provided with a radius. This has the advantage of an increased strength as a result of a favorable grain profile and of improving the flow properties of the material. The transition radius is preferably arranged on the outer side of the tube, but may also be provided in the inflow region of the tube at the tube plate. The latter option would further reduce the pressure drop on the primary side.

According to a further advantageous configuration of the invention, the heat exchanger according to the invention is used as charge-air cooler for internal combustion engines of motor vehicles, specifically as a primary cooler or intercooler of a supercharging system. This creates an inexpensive solution which allows effective cooling of the charge air even at high supercharging pressures and correspondingly high temperatures and at the same time allows conventional charge-air coolers to continue to be used.

Exemplary embodiments of the invention are illustrated in the drawing and described in more detail in the text which follows, in which:

Fig. 1 shows a first exemplary embodiment of the invention with impact-extruded tube plate and tube bundle, and

Fig. 2 shows a second exemplary embodiment of the invention with impact-extruded tube plate, tube bundle and housing.

Fig. 1 shows an exploded view of a charge-air cooler 1 for an internal combustion engine (not illustrated) of a motor vehicle. The charge-air cooler 1 comprises the following parts, illustrated from left to right in the drawing: an inlet connection piece 2, a tube bundle 3 with tube plate 4, a cylindrical housing 5 formed as a housing sleeve, and an outlet connection piece 6. The tube bundle 3 comprises a multiplicity of tubes 3a which are formed integrally with the tube plate 4 and each have a rectangular cross section of flow 3b. The tube plate 4 and the adjoining tubes 3a are produced by impact extrusion, i.e. a known process related to other forms of extrusion. The starting material used is an aluminum extrusion alloy, which is forced through a die (not shown) having the geometry and arrangement of the tubes 3a. The cross section of the tubes 3a and their length and wall thickness can be selected as desired on account of the impact-extrusion process and the corresponding die. The tubes 3a are therefore fixedly and tightly connected to the tube plate 4 and fundamentally require no further treatment. The tube bundle 3 has an end side 3c which faces away from the tube plate 4 and is provided in a conventional way with a second tube plate (not illustrated). All the parts, which preferably consist of aluminum alloys, are soldered together to form a complete heat exchanger. On its circumference, the housing sleeve 5 has an inlet connection piece 7 and, diagonally opposite the latter, an outlet connection piece 8, so that a cooling chamber 9, through which the coolant of an engine cooling circuit (not shown) can flow, is formed between the two tube plates and the housing sleeve 5. The coolant therefore flows between the tubes 3a and around the

tube bundle 3. The hot charge air, illustrated by an arrow LL, enters through the inlet connection piece 2, which is of diffusor-like design, so that the charge air is distributed uniformly over the area of the tube plate 4 and the individual tube cross sections 3b. The charge air flows through all the tubes 3a of the tube bundle 3 and leaves the tube bundle 3 on the opposite side 3c by entering the outlet connection piece 6. The fully assembled charge-air cooler 1 is inserted into a charge-air line (not shown), which is connected flush to the inlet connection piece 2 and the outlet connection piece 6. Therefore, the charge air flows through the charge-air cooler 1 in a straight line, i.e. without any diversions, which leads to a low pressure loss.

Fig. 2 shows a further exemplary embodiment of the invention, namely a charge-air cooler 10 with a housing 11 which has been produced integrally with a tube plate 12 by impact extrusion, a tube bundle (which is not visible), represented by one tube 13 portrayed by dashed lines, being formed integrally with the tube plate 12 and likewise having been produced by impact extrusion. In this exemplary embodiment, therefore, three components or modules, namely tube bundle, tube plate and housing, have been produced integrally in one process step by impact extrusion. A conventionally manufactured tube plate 14 is attached to the downstream end (not visible) of the tube bundle 13 and is joined both to the tubes 13 and to the housing 14, so as to form a cooling chamber for the coolant within the housing 11. As in the exemplary embodiment shown in Fig. 1, an inlet connection piece 15 and an outlet connection piece 16, which are joined to the housing sleeve 11, are fitted into the inlet and outlet ends of the housing 11. All the parts consist of aluminum alloys and are preferably soldered together.

The charge-air coolers 1, 10 shown in Fig. 1 and Fig. 2 are preferably used as a primary cooler or intercooler in a supercharging system for an internal combustion engine. Both charge-air coolers are all-aluminum coolers and are therefore able to withstand charge-air temperatures of up to over 300 degrees Celsius, which is also achieved by a stress-optimized design. In the case of primary cooling, the charge air is precooled to approx. 260 degrees and can then be fed to a conventional charge-air cooler in order to be cooled further.